REMARKS

Claims 1, 3-4, 17, 21-22, and 24 are amended, no additional claims are canceled in this response, and claims 28-30 are added; as a result, claims 1-5 and 17-30 are now pending in this application.

No new matter has been added through the amendments to claims 1, 3-4, 17, 21-22, and 24. Support for the amendments to claims 1, 3-4, 17, 21-22, and 24 may be found throughout the specification, for example but not limited to, the specification at page 3, lines 3-10, and at page 8, lines 20-21. Further support for the amendments to claims 1 and 17 may be found for example, but not limited to, the specification from page 5, line 20 through page 7, line 2, and in claim 2 as originally filed in the application, and in FIG. 2 as originally filed in the application. Further support for the amendments to claim 21 may be found for example, but not limited to, the specification at page 7, lines 25-26. Further support for the amendments to claim 24 may be found for example, but not limited to, the specification at page 8, lines 13-20.

No new matter has been added by the addition of new claims 28-30. Support for new claims 28-30 may be found throughout the specification, for example but not limited to, the specification at page 7, lines 20-29.

§112 Rejection of the Claims

Claims 1-5 and 17-27 were rejected under 35 U.S.C. § 112, first paragraph, as containing subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention. Applicants respectfully traverse this rejection for the reasons set forth below.

Each of independent claims 1, 17, 21, and 24 has now been amended to recite, "injecting a mixture including a phase change material and a number of particles into the cavity." Support for this subject matter may be found in the written description of the application at page 8, lines, 20-21 as originally filed. Applicants submit that that the proposed amendments to independent claims 1, 17, 21, and 24 overcome the 35 U.S.C. § 112, first paragraph rejection of claims 1-5 and 17-27, and so respectfully request reconsideration and withdrawal of this rejection, and allowance of claims 1-5 and 17-27.

Claims 1-5 and 17-27 were rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicants regard as the invention. Applicants respectfully traverse this rejection for the reasons set forth below.

For reasons analogous to those stated above, Applicants submit that the 35 U.S.C. § 112, second paragraph rejection of claims 1-5 and 17-27 have been overcome, and so respectfully request reconsideration and withdrawal of this rejection, and allowance of claims 1-5 and 17-27.

§102 Rejection of the Claims

Claims 1-2 and 4-5 were rejected under 35 U.S.C. §102(b) as being anticipated by or, in the alternative, under 35 U.S.C. §103(a) as obvious over Sotani et al. (JP 358110994A). Applicants respectfully traverse this rejection for the reasons set forth below.

Claims 1-2 and 4-5 are not anticipated by Sotani et al. because Sotani et al. fails to teach all of the claimed subject matter included in claims 1-2 and 4-5. Further, claims 1-2 and 4-5 are not obvious in view of Sotani et al., because Sotani et al. fails to teach or suggest all of the claimed subject matter included in claims 1-2 and 4-5.

For example, independent claim 1 as now amended recites, "forming an integrated circuit heat sink." In contrast, Sotani et al. states, "A rotary heat pipe in which metal particles and a working fluid are sealed inside a tubular member,"[1] and further, Sotani et al. states, "In recent years, rotary heat pipes have been used for devices such as motor shafts."[2]

Thus, Sotani et al. concerns a rotary heat pipe used for devices such as a motor shaft, but fails to disclose "forming an integrated circuit heat sink," as required by the subject matter included in independent claim 1. Because Sotani fails to disclose all of the subject matter as included in independent claim 1, independent claim 1 is not anticipated by Sotani.

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[1] *See* Sotani et al., under the subheading "2. SCOPE OF PATENT CLAIMS."
Note - Applicants' representative have provided in Appendix A of this response a copy of an translation to English of Japanese Unexamined Patent Application Publication - S58-110994, 3 pages total.
[2] *See* Sotani et al., second full sentence under the subheading "3. DETAILED DESCRIPTION OF THE INVENTION."

For at least the reasons stated above, Sotani et al. fails to teach or suggest all of the subject matter included in independent claim 1, and so independent claim 1 is also not obvious in view of Sotani et al.

Claims 2 and 4-5 depend from independent claim 1, and so include all of subject matter recited in independent claim 1, and more. For at least the reasons stated above with respect to independent claim 1, claims 2 and 4-5 are not anticipated, and are also not obvious, in view of the disclosure of Sotani et al.

Applicants respectfully request reconsideration and withdrawal of the rejection, and allowance of claims 1-2 and 4-5.

§103 Rejection of the Claims

Claims 1-2, 4-5, and 17-24

Claims 1-2, 4-5, and 17-24 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Elwell et al.(U.S. 5,315,154) in view of Hanrahan (U.S. 5,945,217). Applicants respectfully traverse this rejection for the reasons set forth below.

Applicants do not admit that Hanrahan is prior art and reserve the right, as provided for under 37 C.F.R. 1.131, to "swear behind" Hanrahan at a later time. However, Applicants do not believe there is a need to swear behind Hanrahan at this time because claims 1-2, 4-5, and 17-24 are distinguishable over the cited documents used in making this rejection of claims 1-2, 4-5, and 17-24.

The Office Action fails to provide proper evidence to support a suggestion or motivation to combine[3] Elwell et al. with Hanrahan, and also fails to show how these documents, or any other evidence of record, suggests the desirability[4] of the proposed combination of Elwell et al. and Hanrahan. In an attempt to meet these requirements, the Office Action on pages 4-5 states,

> It would have been obvious one having ordinary skill in the art at the time the invention was made to use Hanrahan's teaching in

[3] The Office Action must provide specific, objective evidence of record for a finding of a suggestion or motivation to combine reference teachings and must explain the reasoning by which the evidence is deemed to support such a finding. *In re Sang Su Lee*, 277 F.3d 1338, 61 USPQ2d 1430 (Fed. Cir. 2002).

[4] The fact that references can be combined or modified does not render the resultant combination obvious unless the prior art also suggests the desirability of the combination. *In re Mills*, 916 F.2d 680, 16 USPQ2d 1430 (Fed. Cir. 1990); MPEP § 2143.01.

> Elwell's apparatus to effectively dissipate heat from the die. Since Elwell and Hanrahan are both from the same field of endeavor and/or analogous art, it would have been obvious to one having ordinary skill in the art at the time the invention was made to use Hanrahan's teaching in Elwell's apparatus for the purpose of effectively dissipating heat from the die.

However, the Office Action fails to point to any portion of the written description in either Elwell et al. or in Hanrahan, or to any other evidence, to support these statements. Further, the Office Action fails to provide an indication of the desirability of forming the proposed combination. Without such a showing, the Office Action fails to meet the requirements for forming the proposed combination of Elwell et al. with Hanrahan, and so fails to meet the burden to show a *prima facie* case of obviousness with respect to claims 1-2, 4-5, 17-24.

Even if the proposed combination of Elwell et al. and Hanrahan could be formed (wherein Applicants expressly disagree that it could), the proposed combination of Elwell et al. and Hanrahan still fails to teach or suggest all of the subject matter included in each of claims 1-2, 4-5, and 17-24, and so claims 1-2, 4-5, and 17-24 are not obvious in view of this proposed combination of documents.

For example, independent claim 1 as now amended recites,

> forming a metal conductive structure having a cavity, the cavity including a cavity surface sloping upward from a low area located at a center of the cavity surface.

In contrast, Elwell et al. states, ". . . an electronic assembly 10 embodying the present invention includes a thermally conductive heat sink or substrate 12 having a surface 12a on which an electronic component 14 is mounted."[5] Elwell et al. further states, "The substrate 12 is made of aluminum or other suitable material having high thermal conductivity, and is illustrated as including elements in the form of fins 12b which extend away from a surface 12c thereof."[6] However, there is no disclosure or suggestion in Elwell et al. of "forming a metal conductive structure having a cavity, the cavity including a cavity surface sloping upward from a low area located at a center of the cavity surface," as recited in independent claim 1.

[5] *See* Elwell et al., column 2, lines 58-62.
[6] *See* Elwell et al., column 2, line 66 through column 3, line 1.

In addition, Hanrahan states, "The thermally conductive interface 10 is mounted between two representative components, a heat sink 12 and an integrated circuit device 14, on an electronic circuit board 16."[7] However there is no disclosure or suggestion in Hanrahan of, "forming a metal conductive structure having a cavity, the cavity including a cavity surface sloping upward from a low area located at a center of the cavity surface," as recited in claim 1. Thus, neither Elwell et al. nor Hanrahan, when considered either alone or in combination, teach or suggest all of the claimed subject matter included in independent claim 1.

In further examples, independent claim 17 as now amended recites,

> forming a metal conductive structure having a cavity and a plurality of fins, the cavity including a cavity surface having a plurality of ramp structures formed on the cavity surface.

Independent claim 21 as now amended recites,

> injecting a mixture including a phase change material and a number of particles into the cavity, wherein each particles in the number of particles has a density about equal to the density of the phase change material.

Independent claim 24 as now amended recites,

> forming a pair of symmetrical structures, each of the pair of symmetrical structures substantially identical to the other, each of the pair of symmetrical structures having a volume.

As was the case with respect to independent claim 1, there is no teaching or suggestion in the proposed combination of Elwell et al. and Hanrahan of the subject matter included in each of independent claims 17, 21, and 24 and as quoted above. Thus, neither Elwell et al. nor Hanrahan, when considered either alone or in combination, teaches or suggests all of the claimed subject matter included in each of independent claims 17, 21, and 24.

Claims 2 and 4-5 depend from independent claim 1, and so each include all of the subject matter recited in independent claim 1, and more. Claim 18-20 depend from independent claim 17, and so each include all of the subject matter recited in independent claim 17, and more

[7] *See* Hanrahan, column 3, lines 33-36.

Claims 22-23 depend from independent claim 21, and so include all of the subject matter recited in independent claim 21, and more. For at least the reasons stated above with respect to independent claims 1, 17, and 21, the proposed combination of Elwell et al. and Hanrahan fails to teach or suggest all of the subject matter included in each of claims 2, 4-5, 18-20, and 22-23.

Because the proposed combination of Elwell et al. and Hanrahan fails to teach or suggest all of the subject matter include in claims 1-2, 4-5, and 17-24, claims 1-2, 4-5, and 17-24 are not obvious in view of the proposed combination of Elwell et al. and Hanrahan.

For at least the reasons stated above, the 35 U.S.C. § 103(a) rejection of claims 1-2, 4-5, and 17-24 are improper. Applicants respectfully request reconsideration and withdrawal of the rejection, and allowance of claims1-2, 4-5, and 17-24.

Claims 3 and 21-23

Claims 3 and 21-23 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Elwell et al. and Hanrahan as applied to independent claim 1 above and further in view of Salyer (U.S. 5,371,814). Applicants respectfully traverse this rejection for the reasons set forth below.

As argued above, the Office Action fails to provide proper evidence to support a suggestion or motivation to combine Elwell et al. with Hanrahan, and also fails to show how these cited documents, or any other evidence of record, suggest the desirability of the proposed combination of Elwell et al. and Hanrahan. Because the Office Action provides no additional statements with respect the formation of the proposed combination of Elwell et al. and Hanrahan in forming the proposed combination of Elwell et al., Hanrahan, and Salyer, the Office Action also fails to meet the requirements for forming the proposed combination of Elwell et al., Hanrahan, and Salyer. By failing to meet these requirements, the Office Action fails to meet the burden to show a *prima facie* case of obviousness with respect claims 3 and 21-23.

Even if the proposed combination of Elwell et al., Hanrahan, and Salyer could be formed (wherein Applicants expressly disagree that it could), the proposed combination of Elwell et al., Hanrahan, and Salyer still fails to teach or suggest all of the subject matter included in each of claims 3 and 21-23, and so claims 3 and 21-23 are not obvious in view of this proposed combination of documents.

For example, claim 3 depends from independent claim 1, and therefore includes all of the subject matter as recited in independent claim 1, and more. Claims 22-23 depend from independent claim 21, and therefore include all of the subject matter as recited in independent claim 21, and more. For at least the reasons stated above with respect to independent claims 1 and 21, the proposed combination of Elwell et al. and Hanrahan fails to teach or suggest all of the subject matter included in each of claims 3 and 22-23. Applicants' representatives fail to find in, and there is no disclosure in the Office Action pointing to any portion of Salyer, of a teaching or suggestion in Salyer of the subject matter included in claims 3 and 21-23 and missing from the proposed combination of Elwell et al. and Hanrahan. Thus, the proposed combination of Elwell et al., Hanrahan, and Salyer also fails to teach or suggest all of the subject matter included in each of claims 3 and 21-23, and so claims 3 and 21-23 are not obvious in view of the proposed combination of Elwell et al., Hanrahan, and Salyer.

For at least the reasons stated above, the 35 U.S.C. § 103(a) rejection of claims 3 and 21-23 is improper. Applicants respectfully request reconsideration and withdrawal of the rejection, and allowance of claims 3 and 21-23.

Claims 24-25

Claims 24-25 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Sotani et al. in view of Vinz (U.S. 3,911,547). Applicants respectfully traverse this rejection for the reasons set forth below.

The Office Action fails to provide proper evidence to support a suggestion or motivation to combine Sotani et al. with Vinz, and also fails to show how the documents, or any other evidence of record, suggest the desirability of the proposed combination of Sotani et al. and Vinz.

In an attempt to meet these requirements, the Office Action on page 6 states,

> Vinz discloses (figure 2) a heat sink that has a conductive structure is formed by coupling a pair of symmetrical structure (12, 13) which has approximately one-half of a volume, for a purpose of forming a cavity without using a large piece of material. It would have been obvious to one having ordinary skill in the art at the time the invention was made to use Vinz's teaching in Sotani's

> device for a purpose of forming a cavity without using a large piece of material.

In contrast to these statements made in the Office Action, Vinz states, "The sintering support member 12 is in the form of half-shells 13 and 14 which tightly enclose the coiled strip of the hollow member 10 during sintering, this member being formed as previously described."[8] Vinz further states, "The supporting elements and the base 20 advantageously consist of a ceramic material, e.g. Al2O3."[9]

Thus, Vinz concerns a support member formed of ceramic material, but fails to disclose a "heat sink" as suggested in the Office Action. Further, Applicants' representatives fail to find in Vinz any statements related to, "without using a large piece of material," as also suggested in the Office Action. Thus, the statements made in the Office Action in support of the proposed combination of Sotani et al. and Vinz are not supported, and are actually contradicted by, the written description of Vinz. Further, the Office Action fails to show the desirability of forming the proposed combination "without using a large piece of material" as suggested in the Office Action, with respect to any statements from the written description in either Sotani et al. or Vinz.

Thus, these statements in the Office Action fail to meet the requirements for forming the proposed combination of Sotani et al. and Vinz. By failing to meet these requirements, the Office Action fails to meet the burden to show a *prima facie* case of obviousness with respect the rejection of claims 24 and 25.

Even if the proposed combination of Sotani et al. and Vinz could be formed (wherein Applicants expressly disagree that it could), the proposed combination of Sotani et al. and Vinz fails to teach or suggest all of the subject matter included in claims 24 and 25, and so claims 24 and 25 are not obvious in view of this proposed combination of documents.

For example, independent claim 24 as now amended recites, "forming an integrated circuit heat sink." In contrast, neither Sotani et al. nor Vinz teach or suggest "forming an integrated circuit heat sink," as required by the recitation of independent claim 24. As noted above, Sotani et al. relates to rotary heat pipes, as used for devices such as motor shafts.

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[8] *See* Vinz, column 2, lines 34-37.
[9] *See* Vinz, column 2, lines 41-43.

However, there is no teaching or suggestion in Sotani et al. of "forming an integrated circuit heat sink," as required by the recitation of independent claim 24. In addition, Vinz relates to, ". . . a process for the production of porous tubes having small pores."[10] However, there is no teaching or suggestion in Vinz of, "forming an integrated circuit heat sink," as recited in independent claim 24.

Because neither Sotani et al. nor Vinz, either alone or in combination, teach or suggest all of the subject matter recited in independent claim 24, independent claim 24 is not obvious in view of the proposed combination of Sotani et al. and Vinz.

Claim 25 depends from independent claim 24, and so includes all of the subject matter recited in independent claim 24, and more. Thus, the proposed combination of Sotani et al. and Vinz fails to teach or suggest all of the subject matter included in claim 25.

For at least the reasons stated above, the 35 U.S.C. § 103(a) rejection of claims 24 and 25 is improper. Applicants respectfully request reconsideration and withdrawal of this rejection, and allowance of claims 24 and 25.

Claims 26-27

Claims 26-27 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Sotani et al. and Vinz as applied to claim 24, and further in view of Munekawa et al. (U.S. 5,076,351). Applicants respectfully traverse this rejection for the reasons set forth below.

As noted above, the Office Action fails to provide proper evidence to support a suggestion or motivation to combine Sotani et al. with Vinz, and also fails to show how the documents, or any other evidence of record, suggest the desirability of the proposed combination of Sotani et al. and Vinz. Because the Office Action provides no additional statements with respect the formation of the proposed combination of Sotani et al. and Vinz in forming the proposed combination of Sotani et al., Vinz, and Munekawa et al., the Office Action also fails to meet the requirements for forming this proposed combination of Sotani et al., Vinz, and Munekawa et al.

In addition, in an attempt to meet these requirements, the Office Action on page 6 states,

[10] *See* Vinz, column 1, lines 4-5.

> Munekawa et al. discloses (figures 9-10) fins (66) are brazed on the outside surface of the conductive structure for a purpose of increasing the heat transfer surface area of the conductive structure. It would have been obvious to one having ordinary skill in the art at the time the invention was made to use Munekawa's teaching in the combination device of Sotani an Vinz for a purpose of increasing the heat transfer surface area of the conductive structure.

However and in contrast, as noted above the "support members" in Vinz are fabricated of ceramic material, and thus are not concerned with heat transfer as suggested in the Office Action. Further, Sotani et al. is concerned with motor shafts, and the Office Action fails to explain how the brazing of fins *to the outside surface of the motor shaft* of Sotani et al. would be desirable, or would not destroy the stated purpose of the heat pipe of Sotani et al. for use as a motor shaft. Brazing fins onto an outside surface of a motor shaft would appear to prevent the shaft from being coupled to another device, and thus would destroy the stated purpose of the heat pipe in Sotani et al.

For at least these reasons, these statements in the Office Action fail to meet the requirements for forming the proposed combination of Sotani et al., Vinz, and Munekawa et al. By failing to meet these requirements, the Office Action fails to meet the burden to show a *prima facie* case of obviousness with respect to the rejection of claims 26 and 27.

Even if the proposed combination of Sotani et al., Vinz, and Munekawa et al. could be formed (wherein Applicants expressly disagree that it could), the proposed combination fails to disclose or suggest all of the subject matter included in claims 26-27, and so claims 26-27 are not obvious in view of this proposed combination of documents.

For example, claims 26-27 depend from independent claim 24, and so include all of the subject matter included in independent claim 24, and more. For at least the reasons stated above with respect to independent claim 24, the proposed combination of Sotani et al. and Vinz fails to teach or suggest all of the subject matter included in independent claim 24, and thus fails to teach or suggest all of the subject matter include in claims 26-27. Applicants' representatives fail to find in, and there is no disclosure in the Office Action pointing to any portion of Munekawa et al., of a teaching or suggestion in Munekawa et al. of the subject matter included in claims 26

and 27 and missing from the proposed combination of Sotani et al. and Vinz. Because Sotani et al., Vinz, and Munekawa et al., when taken either alone or in combination, fail to teach or suggest all of the subject matter recited in claims 26 and 27, claims 26 and 27 are not obvious in view of the proposed combination of Sotani et al., Vinz, and Munekawa et al.

For at least the reasons stated above, the 35 U.S.C. § 103(a) rejection of claims 26 and 27 is improper. Applicants respectfully request reconsideration and withdrawal of this rejection, and allowance of claims 26 and 27.

Conclusion

Applicant respectfully submits that the claims are in condition for allowance and notification to that effect is earnestly requested. The Examiner is invited to telephone Applicant's attorney ((612) 371-2132) to facilitate prosecution of this application.

If necessary, please charge any additional fees or credit overpayment to Deposit Account No. 19-0743.

Respectfully submitted,

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CERTIFICATE UNDER 37 CFR 1.8: The undersigned hereby certifies that this correspondence is being filed using the USPTO's electronic filing system EFS-Web, and is addressed to: MS Amendment, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on this 20th day of September 2006.

Amy Moriarty
Name

Signature

Appendix A

Translation to English of Japanese Unexamined Patent Application Publication - S58-110994 (3 pages).

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(54) ROTARY HEAT PIPE

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SPECIFICATION

1. TITLE OF THE INVENTION

Rotary heat pipe

2. SCOPE OF PATENT CLAIMS

A rotary heat pipe in which metal particles and a working fluid are sealed inside a tubular member.

3. DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to a rotary heat pipe.

In recent years, rotary heat pipes have been used for devices such as motor shafts. A motor shaft formed from a rotary heat pipe improves the number of years of durability of the motor by increasing the heat transmission performance and decreasing the temperature of the heat generating part using water as an operating fluid. However, when iron is used as the material for the tubular member that constitutes the rotary heat pipe, there is a problem in which noncondensable gas is generated inside the heat pipe due to the reaction of iron with water. In order to solve this problem, a device in which the tubular member that constitutes the rotary heat pipe is formed as a so-called double pipe is used, wherein a copper pipe is inserted as an inner pipe inside an outer pipe made of iron, for example, and these pipes are adhered as a unit after an operating fluid is sealed inside this inner pipe. However, a rotary heat pipe that uses such a double pipe structure has the drawbacks that the structure is complex, causing the manufacturing cost to increase, and the adhesion resistance of the inner pipe and the outer pipe is large, resulting in reduced heat transmission performance. Further, rotary heat pipes configured such that the inner pipe is removed and an operating fluid that does not react with iron such as methanol is sealed inside a tubular member made of iron have also been manufactured, but a rotary heat pipe that uses such an operating fluid has the drawback that the heat transmission properties are inferior to those of rotary heat pipes with the double pipe structure described above.

Moreover, with a rotary heat pipe that is used as a motor shaft, a shortage in operating fluid develops when the motor shaft is installed at a slight incline, and in order to prevent this from interfering with its action as a heat pipe, a quantity of operating fluid that is larger than necessary (normally, this is approximately 15 to 40% of the inside volume of the tubular member) is sealed inside. Increasing the quantity of operating fluid in this way results in the problem that the vaporization action and condensation action of the operating fluid are diminished, causing the deterioration of heat transmission properties.

The present invention was conceived in light of the issues described above, and it provides a rotary heat pipe that has excellent heat transmission properties and enables the reduction of manufacturing costs.

In other words, the present invention is a rotary heat pipe in which metal particles and a working fluid are sealed inside a tubular member.

An example of embodiment of the present invention will be described below with reference to the drawings.

Figure 1 is a cross-sectional view of an embodiment of the present invention. In the figure, 1 is a tubular member made of a ferrous metal. Both ends of tubular member 1 are closed by cover members 2 and 3. An operating fluid 4 such as methanol that does not react with iron is sealed on the inside of tubular member 1 enclosed by tubular member 1 and cover members 2 and 3. Metal particles 5 made of metal such as iron or copper are immersed in operating fluid 4.

Here, as metal particles 5, it is desirable to use spherical particles that can move easily in step with the rotation of tubular member 1, have large surface area, and can increase the vaporization action and condensation action of operating fluid 4. It is normally preferable to set the diameter of metal particles 5 to approximately 1–8 mm.

When rotary heat pipe 10 that is configured in this way is used as a motor shaft while it is rotated at an incline with a heat absorbing part on the bottom, it demonstrates the following action and effects when rotated at a low speed. As shown in Figure 2, when the heat pipe is rotated at a low speed, metal particles 5 are deposited on the inside wall of the bottom of tubular member 1. As a result, operating fluid 4 accumulates in the heat absorbing part, which is on the bottom (this accumulation part of operating fluid 4 is called the "paddle part" hereafter), and metal particles 5 are immersed in the paddle part, resulting in a state in which operating fluid 4 becomes attached to the surface of metal particles 5. Therefore, the liquid film of operating fluid 4 in the paddle part becomes thin because it is restricted by the inside wall surface of tubular member 1 and the surface of metal particles 5. As a result, the heat transmission rate due to operating fluid 4 in the heat absorbing part is dramatically increased. This is considered to be due to the fact that the heat transmission area is increased because the liquid film of operating fluid 4 of the heat absorbing part becomes thin due to the presence of metal particles 5, and the fact that boiling is facilitated as a result of the generation of a boiling cavity between metal particles 5 and the inside wall surface of tubular member 1 and between metal particles 5 and metal particles 5. Incidentally, it was experimentally confirmed that the heat transmission rate of operating fluid 4 in the heat absorbing part is increased by approximately 2–3 times in comparison to the case of a conventional rotary heat pipe that does not have metal particles 5. Further, a portion of metal particles 5 that protrude from the paddle part are also present in the heat dissipation part of rotary heat pipe 10 in a state in which the surface is exposed from the liquid surface of operating fluid 4. As a result, the dropwise condensation and the filmwise condensation of operating fluid 4, which is vaporized on the inside wall surface of tubular member 1 of the heat dissipation part and the surface of metal particles 5, occur, and the heat transmission rate is dramatically increased. Incidentally, it has been experimentally confirmed that the heat transmission rate is increased by approximately 1.5 times in comparison to the case of a conventional rotary heat pipe that does not have metal particles 5.

Further, when the rotary heat pipe is rotated at a high speed, as shown in Figure 3, metal particles 5 spread out with a uniform distribution over the entire inside wall surface of tubular member 1. The liquid film of operating fluid 4 is also obviously made extremely thin in step with this spreading out of metal particles 5, and it spreads out between metal particles 5 and the inside wall surface of tubular member 1, focused on the heat absorbing part. As a result, the vaporization action and the condensation action of operating fluid 4 are even further improved over the case of low-speed rotation. Incidentally, it has been experimentally confirmed that the heat transmission rate in the heat absorbing part is increased by 1.5–2.5 times and the heat transmission rate in the heat dissipation part is increased by approximately 2 times in comparison to the case of a rotary heat pipe that does not have metal particles 5.

The heat transmission rate can be dramatically increased in this way, thus improving the heat transmission properties. Further, because tubular member 1 has a single pipe structure, the manufacturing cost can be reduced.

As described above, the rotary heat pipe of the present invention demonstrates the noteworthy effects that it has excellent heat transmission properties and the manufacturing cost can be reduced.

4. BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a cross-sectional view of an embodiment of the present invention. Figure 2 is a cross-sectional view along line II–II in this embodiment. Figure 3 is a cross-sectional view showing the state of the rotary heat pipe of the embodiment when it is in operation.

1 ... tubular member, 2 and 3 ... cover members, 4 ... operating fluid, 5 ... metal particles, 10 ... rotary heat pipe.

FIGURE 1

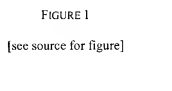

FIGURE 2

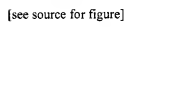

FIGURE 3